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Spinek, Thomas R.

Hall, Leo M.

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Thomas R. Spinek and Leo M. Hall
Department of Geology and Geography
University of Massachusetts
Amherst, Massachusetts 01003

INTRODUCTION

Detailed stratigraphy and structural geology of the Bethel area, along the east-central edge of the Fordham Terrane (Hall, 1980) will be examined on this field trip. The Bethel area straddles Cameron's Line, a major tectonic and stratigraphic boundary interpreted to be a thrust fault. The general stratigraphy and structural history of this area is correlated with the stratigraphy and structural framework proposed for the White Plains-Glenville area of southeastern New York and southwestern Connecticut by Hall (1968a, 1976, 1980). This correlation is based on detailed mapping, structural analysis, and petrographic study of the bedrock in the Bethel area.

REGIONAL SETTING

The Bethel area (Fig. 1) is situated at the east-central edge of the Fordham Terrane, a northeast trending belt of Precambrian basement rocks that are unconformably overlain by metamorphosed autochthonous rocks, that in turn are overridden by allochthonous Cambrian-Ordovician cover rocks. The eastern part of the Bethel area is underlain by metamorphosed allochthonous Lower Paleozoic rocks known as "eastern region cover rocks" (Hall, 1980), and associated mafic and ultramafic plutonic igneous rocks. Other metamorphosed Paleozoic intrusive rocks, such as the Siscowit Granite Gneiss and related rocks are also present in the region (Figs. 1 and 2).

The Bethel area underwent a complex tectonic history including the effects of the Grenvillian, Teconian, Acadian, and possibly Alleghenian orogenies. Rocks in the western part of the area are in the sillimanite-K-feldspar zone of Paleozoic regional metamorphism but the grade of metamorphism decreases eastward in the Bethel area to the kyanite zone. The metamorphic history of the rocks is complex, as Acadian metamorphic effects overlap Taconian metamorphic effects. Furthermore, Precambrian rocks in the Bethel area contain evidence of relict granulite facies metamorphism and are intimately involved in all phases of Paleozoic deformation and metamorphism along with the cover rocks.

STRATIGRAPHY

Three main subdivisions of stratified bedrock are present in the

Figure 1. Generalized geologic map of southwestern Connecticut and adjacent New York (modified from Hall, 1980). The Bethel area is outlined south of Danbury.

Explanation

INTRUSIVE ROCKS

FELSIC PLUTONS

MAFIC PLUTONS

STRATIGRAPHIC UNITS

TRIASSIC – JURASSIC

SILURIAN – DEVONIAN

Western Region

CAMBRIAN - ORDOVICIAN

Autochthonous Cover Rocks

Allochthonous Cover Rocks

Eastern Region

CAMBRIAN – ORDOVICIAN

Cover Rocks

BASEMENT UNITS

AVALONIAN AGE BASEMENT
Yonkers and Pound Ridge Gneisses

GRENVILLE BASEMENT

PRECAMBRIAN - LOWER ORDOVICIAN
Basement Gneisses of Uncertain Age

Explanation

INTRUSIVE ROCKS

ORDOVICIAN

- ?Osg — Siscowit Granite Gneiss
- ?Ob — Brookfield Gneiss
- ?Ou — Ultramafic Rocks — Serpentinite, Hornblendite, Pyroxenite

STRATIGRAPHIC UNITS

Western Region: Autochthonous	Western Region: Allochthonous	Eastern Region: Allochthonous
MIDDLE ORDOVICIAN Oma — Manhattan A		
unconformity		
CAMBRIAN AND/OR ORDOVICIAN O€i — Inwood Marble €l — Lowerre Quartzite	€mc — Manhattan C	O€ht — Hartland Formation
unconformity		
PRECAMBRIAN — Fordham Gneiss p€fb — Biotite - Hornblende Gneiss Member p€fg — Garnet-Biotite Gneiss and Amphibolite Member p€fl — Layered Gneiss Member		

SYMBOLS

- Thrust Fault (teeth in allochthon)
- Cameron's Line Thrust Fault (teeth in allochthon)
- Normal Fault (hachures on downthrown side)
- ② Trip Route and Stop Numbers

Figure 2. Generalized geologic map of the Bethel area.

73° 30'
41° 22' 30"
73° 30'
pЄfb
pЄfl
pЄfg
Oma
Єmc
OЄi
OЄht
Єl
?Ou
?Ob
?Osg
A
A'
B
B'
Bethel Area
Mapped by Spinek
Mapped by Brandon (1981)
0
1 MILE
0
1 KILOMETER

Bethel area. These subdivisions are: 1) Precambrian (Grenvillian) gneisses, amphibolites, calc-silicate rocks, and marbles, 2) Cambrian and Ordovician autochthonous and allochthonous rocks west of Cameron's Line, 3) Cambrian and Ordovician allochthonous rocks east of Cameron's Line (Fig. 2).

The Precambrian Fordham Gneiss has been subdivided into three members in the Bethel area (Fig. 2). Their age sequence, from oldest to youngest, is uncertain and the sequence shown on the geologic map was chosen arbitrarily. The members of the Fordham Gneiss mapped in the Bethel area are the Layered Gneiss Member, the Garnet-Biotite Gneiss and Amphibolite Member and the Biotite-Hornblende Gneiss Member. Within these members are other thin mappable horizons including distinctive garnetiferous gneisses, calc-silicate rocks and marbles, not shown in Figure 2. The Biotite-Hornblende Gneiss Member is physically continuous with rocks mapped in the adjoining Ridgefield area (Brandon, 1981). Although there are lithic similarities between the members of the Fordham Gneiss in the Bethel area with subdivisions of the Fordham Gneiss elsewhere (Hall, 1968b, 1968c; Alavi, 1975; Brandon, 1981) in southeastern New York and southwestern Connecticut, no specific correlation between these units is made.

The Fordham Gneiss is interpreted by Hall (1968a, p. 121) as "a predominantly clastic and volcanic eugeosynclinal sequence that has undergone high grade metamorphism". Although no truncation of contacts between the three members of the Fordham Gneiss by the angular unconformity at the base of the Paleozoic rocks can be demonstrated in the Bethel area, mappable rock types within the Biotite-Hornblende Gneiss Member (not shown on figure 2) are truncated by the basal Paleozoic unconformity. Hall (1968a) has recognized multiple fold patterns defined by the map patterns of members of the Fordham Gneiss that are truncated by this angular unconformity.

Cambrian and Ordovician autochthonous and allochthonous rocks west of Cameron's Line are interpreted to have been deposited on continental and/or transitional crust. The Fordham Gneiss is unconformably overlain by Cambrian quartzites, granulites, and schists of the Lowerre Quartzite (Stop 1) and the Cambrian-Ordovician Inwood Marble (Stops 2 and 7). The eastern exposures of the Lowerre Quartzite consist of sillimanite-garnet-biotite schist whereas western exposures are predominantly clean quartzites and biotite-quartz-feldspar granulites. It has been suggested (Hall, et al., 1975; Jackson and Hall, 1982) that these different rocks in the Lowerre represent a facies change from west to east and may represent a partial time-transgressive sequence with the rocks in the east deposited prior to those in the west. The Inwood Marble has been divided into two members in the Bethel area, not shown separately in Figure 2. There is a basal member, Inwood A, of thick bedded clean dolomite marble, and an upper member, Inwood B, consisting of interlayered thin bedded clean dolomite marble, silicate-rich dolomite marble, and lesser calc-schists and brown-weathering quartzites. Middle Ordovician calcite marble and rusty-weathering schists and granulites of Manhattan A (Stop 3) unconformably overlie basement and western region autochthonous rocks.

The western region autochthonous stratigraphy is physically overlain by an allochthonous sequence of schists, schistose-gneisses, gneisses, granulites, and lesser quartzites, interpreted to be Cambrian and/or Ordovician. These rocks, Manhattan C, (Stop 4) are thought to be an eastern facies of the basal clastics and carbonate bank sequence deposited primarily on Grenville basement (Hall, et al., 1975; Hall, 1980).

A major tectonic boundary, Cameron's Line (Rodgers, et al., 1956; Hall, 1980; Merguerian, 1983) separates western region cover rocks and basement described above from eastern region cover rocks and associated mafic and ultramafic plutonic rocks (Fig. 1). Eastern region cover rocks are represented in the Bethel area by the Hartland Formation, a sequence of amphibolites, schists, granulites and gneisses thought to have been deposited on oceanic crust in the Cambrian and Ordovician. The Hartland has been subdivided into three mappable units in the Bethel area but these are not shown separately on the geologic map (Fig. 2).

STRUCTURAL GEOLOGY

The geologic map pattern (Fig. 2) is the result of the Precambrian deformation and a sequence of thrusting, followed by multiple folding during the Paleozoic (Fig. 3). The Bethel area has also been affected by post-metamorphic high-angle faults, that are probably as young as Mesozoic.

The Precambrian Fordham Gneiss in the Bethel area, and elsewhere in the Fordham Terrane, underwent at least one phase of intense deformation and associated granulite facies metamorphism during the Grenvillian Orogeny. This deformation produced folds, associated axial plane foliations and other structural features that are truncated by the basal Paleozoic angular unconformity.

The first phase of Paleozoic deformation involved large-scale west directed thrusting that may have been accompanied by local isoclinal folding, particularly in the allochthonous rocks. During this phase of deformation Manhattan C was thrust onto the autochthonous sequence. Apparently, rocks traditionally referred to as part of the authchthonous sequence may also have undergone some thrusting (Figs. 2 and 3). Both the thrust fault that lies beneath Manhattan C and thrust faults within the "autochthonous" sequence are truncated by the Cameron's Line Thrust Fault, which floors the thrust sheet that consists of the Hartland Formation and mafic and ultramafic igneous rocks intruded into the Hartland Formation. The Cameron's Line Thrust Fault has been folded by at least 4 phases of Paleozoic deformation and, in places where it dips steeply, it appears to have been reactivated with post-metamorphic movement along high angle faults that are as young as Mesozoic. Evidence for thrusting along Cameron's Line includes truncation of units above and below the fault, juxaposition of rocks interpreted to be older or equivalent in age atop those thought to be younger or the same age and mylonitic rocks at fault zones.

The first phase of major Paleozoic folding occurred after thrusting along Cameron's Line and involved isoclinal folding of basement, cover rocks on both sides of Cameron's Line, and mafic and ultramafic rocks associated with eastern cover rocks. Foliation produced at this time is the dominant foliation in the rocks, although locally, intense subsequent deformation has produced younger foliations that are locally dominant. A second phase of isoclinal folding refolded earlier folds and produced a well developed axial planar foliation. The third phase of Paleozoic folding produced tight to isoclinal folds and was accompanied by a well developed axial planar foliation and a strong lineation. A fourth phase of Paleozoic folding involved open folds with a locally developed axial planar cleavage, which is a crenulation cleavage in the schistose rocks.

Post-metamorphic high-angle faulting may locally involve reactivation of movement along Cameron's Line where it is steeply dipping.

METAMORPHISM

The Precambrian Fordham Gneiss contains evidence for granulite facies metamorphism, presumably associated with Precambrian deformation during the Grenvillian Orogeny. The assemblage orthopyroxene-clinopyroxene-hornblende-plagioclase is present in local mafic rocks in the Biotite-Hornblende Gneiss Member. This assemblage is exclusive to rocks in the Fordham Gneiss and is interpreted to be evidence for relict granulite facies regional metamorphism during the Precambrian.

Peak regional metamorphism in the Paleozoic cover rocks in the Bethel area at sillimanite-K-feldspar grade. The grade of Paleozoic regional metamorphism decreases from west to east and the rocks at the east edge of the area are in the kyanite zone of regional metamorphism. Evidence for retrograde metamorphism includes the alteration of biotite to Fe-rich and Mg-rich chlorite and alteration of forsterite to serpentine in calc-silicate rock.

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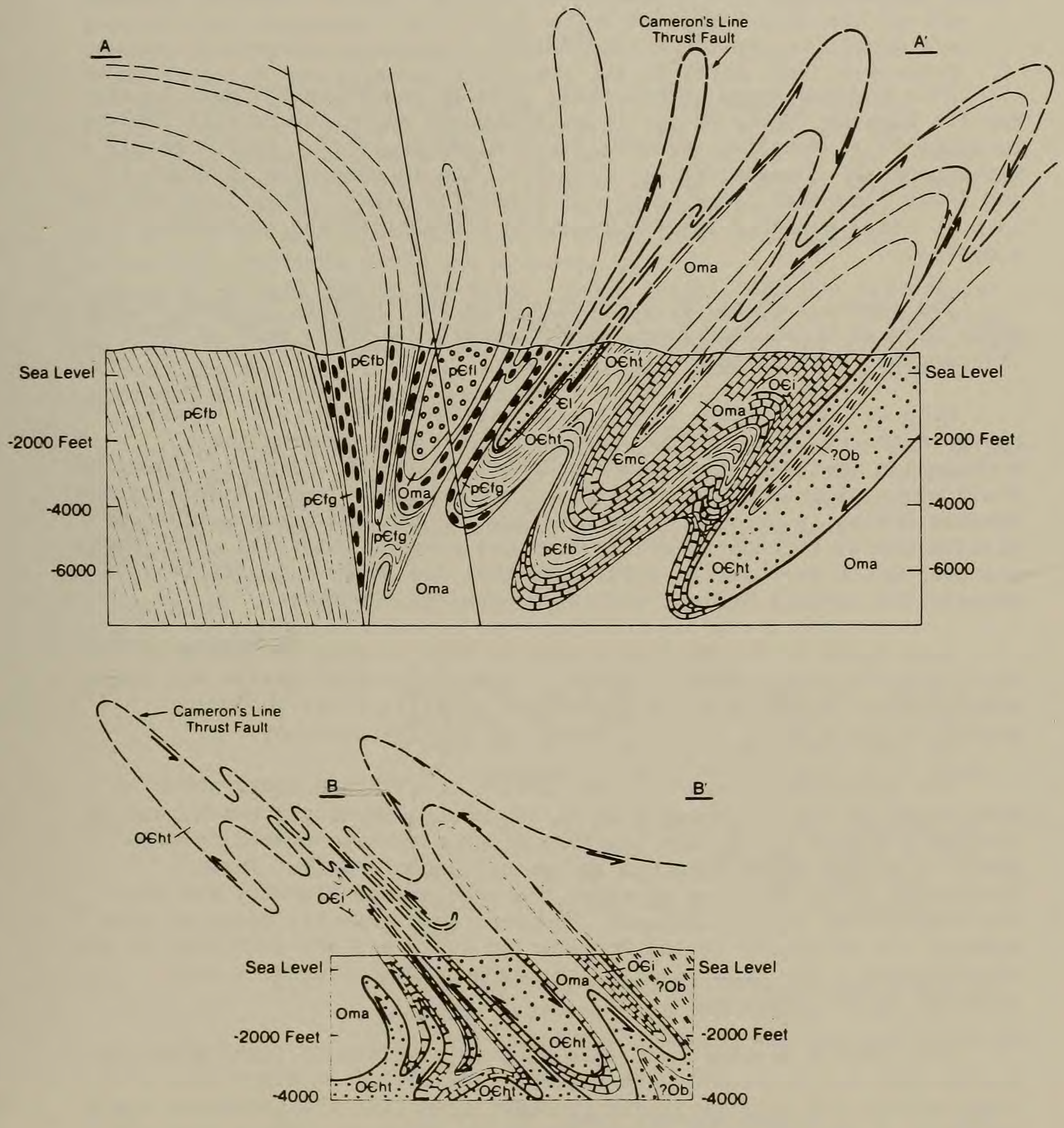

Figure 3. Generalized structure sections A-A′ and B-B′, located on figure 2.

Consolidated Controls Corporation for their cooperation.

ROAD LOG

From the New Haven, Connecticut area follow Route #34 west to the Merritt Parkway (Route #15). Drive southwest along the Merritt Parkway to Route #7 in Norwalk. Proceed north along Route #7. Approximately 4 miles north of Branchville turn right at the intersection of Route #7 and Great Pond Road, where there is a traffic light. This intersection is 0.75 miles south of the intersection of Route #7 and Route #35 in Ridgefield.

The assembly point is the Martin Park parking lot, located on the north side of Great Pond Road, approximately 0.2 miles east of its intersection with Route #7.

Stop 1. Great Pond, Ridgefield. At this stop we will examine rocks in the vicinity of the angular unconformity between the Precambrian Fordham Gneiss and the Cambrian Lowerre Quartzite along the south shore of Great Pond. The Biotite-Hornblende Gneiss Member of the Fordham Gneiss is unconformably overlain by tan- and rusty-weathering, biotite-quartz-feldspar granulites of the Lowerre Quartzite. The rocks are overturned here due to folding so that the Lowerre Quartzite lies beneath the Fordham Gneiss, dipping moderately northwest.

Rock types in the Fordham Gneiss at this outcrop include gray biotite-hornblende gneiss, (biotite) -quartz-feldspar gneiss and black amphibolite. Discordant and concordant granitic rocks including pegmatite are common, and vein quartz is locally abundant.

The unconformity can only be located to within 2 feet, about 15 feet south of the telephone pole at the south end of the beach, due to limited exposure and to the presence of pink biotite-quartz-feldspar granitic gneiss which obscures the actual unconformity. These particular granitic rocks crosscut the angular unconformity and thus are interpreted to be Paleozoic. However, some granitic rocks at this outcrop are exclusive to the Precambrian rocks and are truncated by the unconformity. The unconformity strikes approximately N20°E and dips 30° to 35° northwest.

The Lowerre Quartzite at this outcrop consists of light-gray- to tan-weathering, biotite-quartz-feldspar granulite. A minor amount of rusty-weathering biotite-quartz-feldspar granulite that contains minor sulfides is present on the west edge of the pathway leading from the parking lot to the beach.

Orientations of compositional layers in the Fordham Gneiss differ considerably from place due to complex folding. The dominant orientation of compositional layering is N63°W and dips 73° northeast. However, near the unconformity, the layering in the basement gneisses appears to have been rotated into parallelism with bedding (and Paleozoic first phase axial surface foliation) in the Lowerre Quartzite, presumably due to intense Paleozoic deformation. Minor folds in the gneisses include a set of folds that have axial surfaces that strike N45°W and dip 64°SW. Fold axes of these folds plunge 24°, N62°W. Concordant granitic rocks within the basement gneisses are folded by this set of isoclinal folds. These folds are apparently refolded by a later set of tight to isoclinal folds that have axial surfaces that strike N45°E to N75°E and dip 30° to 35° NW. The fold axes of these later folds plunge 28° to 32°, N55°W to N58°W and a strong quartz lineation is parallel to the axes. These later folds are evident in both the Fordham Gneiss and the Lowerre Quartzite and are interpreted to be third phase Paleozoic folds. Although most of the granitic rocks at this outcrop appear to be folded by these later folds, a granite dike crosscuts them at one location.

A thin mylonite zone, 1 to 2 feet thick, is present in the Fordham near the northeast end of the outcrop. This zone contains a mylonitic pink pegmatite vein. The mylonite zone strikes N70°E and dips 75°NW and displays prominent mineral lineation that plunges N71°W at 25°.

Mileage Total	Interval	
0.0	-	Leave the parking lot and turn left (east) on Great Pond Road. Follow Great Pond Road (also called Picketts Ridge Road) east to its intersection with George Hull Hill Road.
1.4	1.4	Bear right at this intersection, staying on Picketts Ridge Road. Continue south to the intersection of Picketts Ridge Road and Sympaug Turnpike, where there is a stop sign.
2.2	0.8	Turn left onto Sympaug Turnpike and cross the bridge over the railroad tracks. Turn left after crossing the bridge and proceed northeast along Sympaug Turnpike.
3.1	0.9	Outcrop of "West Redding Garnet Rock" (Balk, 1936, map), a contact metamorphic rock predominantly composed of grossular and diposide, is present on the southeast side of the road.
3.4	0.3	Stop sign at West Redding Post Office. Bear right onto Side Cut Road.

3.5	0.1	Bear left on Side Cut Road and continue to its intersection with Route #53.
4.0	0.5	Turn left (north) onto Route #53 and proceed to driveway for Friendly Wood and Wire Fence Company.
5.0	1.0	Turn left into driveway and proceed through main gate to the parking lot at the west edge of the quarry.
5.4	0.4	Parking lot at Limekiln Swimming Association Quarry.

Stop 2. Limekiln Swimming Association Quarry, Bethel (Fig. 2). At this stop we will examine Members A and B of the Inwood Marble in the quarry. We will also make a short traverse along the quarry road to view the Cameron's Line Thrust Fault, which at this locality brings the Hartland Formation in thrust fault contact with Member B of the Inwood Marble.

The contact between Inwood A and Inwood B is exposed at the entrance to the quarry, with Inwood A lying east of and below Inwood B. Inwood A consists of thick bedded, gray to light-gray, clean dolomite marble. Some beds contain sparse phlogopite and iron sulfides. A 2-inch thick dark-gray quartzite is present in Inwood A at this locality.

Inwood B consists of thin bedded, gray- or dark-gray-weathering, gray dolomite marble. Some beds contain abundant phlogopite and green serpentine after forsterite. Iron sulfide minerals are also present in some beds. Clean gray dolomite marbles are characteristically interbedded with silicate-rich dolomite marbles in beds up to 10-12 inches thick. Calc-schist layers are present in Inwood B along the southwest inner wall of the quarry.

Bedding in the Inwood Marble strikes N5°W to N5°E and dips 44° to 46° west. An isoclinal fold in bedding, interpreted to be a first phase Paleozoic fold, is present on the east facing wall on the north side of the quarry entrance. This fold has an axial surface that strikes N-S, and dips 45° west and a fold axis that plunges 44°, N65°W. The 2 inch thick dark-gray quartzite in Inwood A outlines outstanding fold digitations.

We will leave the quarry and travel south along the road by foot. At the hairpin curve in the road 50 feet west of the inner gate we will examine the rocks in the vicinity of the Cameron's Line Thrust Fault. Because of folding this thrust fault is present in two places at the hairpin curve in the road. At this locality the Cameron's Line Thrust

Fault brings the Hartland Formation into contact with Inwood B.

The Hartland Formation here consists of sillimanite-garnet-biotite schist, black biotite-schistose-granulite and thick bedded black amphibolite. The rocks are intensely sheared and this shearing is interpreted to have taken place as the Hartland Formation was thrust over more competant rock prior to the movement which finally placed it in thrust contact with Inwood B. Amphibolite beds in the Hartland strike N32°E and dip 42° west. Minor folds in Inwood B have an axial surface orientation that strikes N17°E and dips 42° west and fold axes that plunge 42°, N26°W. Both destral and sinistral folds, presumably of the same order, are present in the outcrop at the base of the slope on the south side of the hairpin curve. These tight to isoclinal folds are beautifully outlined by the clean dolomite and silicate-mineral-rich dolomite beds of Inwood B.

5.0	-	Return to the vehicles and retrace the route to Route #53.
5.4	0.4	CAUTION. BE CAREFUL WHEN CROSSING ROUTE #53. Turn left (north) onto Route #53 and proceed 0.1 mile to the driveway marked "Pattison" on the right (east).
5.5	0.1	Turn right into the driveway and park on the field north of the driveway.

Stop 3. Pattison's Spur, Bald Rock, and Serpentinite Hill Traverse, Bethel-Redding. This stop includes a traverse along the Cameron's Line Thrust Fault and shows some of the rocks of the autochthonous section beneath Cameron's Line. We will also examine the Hartland Formation, the Brookfield Gneiss and an ultramafic body, all of which are above the thrust fault. Proceed east along the trail that leads from the parking area to the base of the cliffs to the east (Fig. 4).

Station A (Fig. 4) - The Manhattan A Marble Member is exposed at the base of this spur and consists of light-gray-weathering, white to light-gray calcite marble with minor iron sulfides and phlogopite. Interbedded with the marble at this locality are rusty-weathering calcareous granulites and a 10-12 feet thick lens of brown-weathering, sillimanite-garnet-biotite schist, biotite schist, and tan- to brown-weathering calcite marble. Rusty-weathering, siliceous granulites in beds of 1 to 2 inches thick, and thin calc-cilicate rocks are also present. A mappable body of white granite is present in Manhattan A Marble here, and it contains inclusions of schist and marble. Orientations of compositional layering ranges from strikes of N40°E to N50°E and dips of 41°-51° NW.

Proceed up the spur from outcrops of Manhattan A to outcrops at

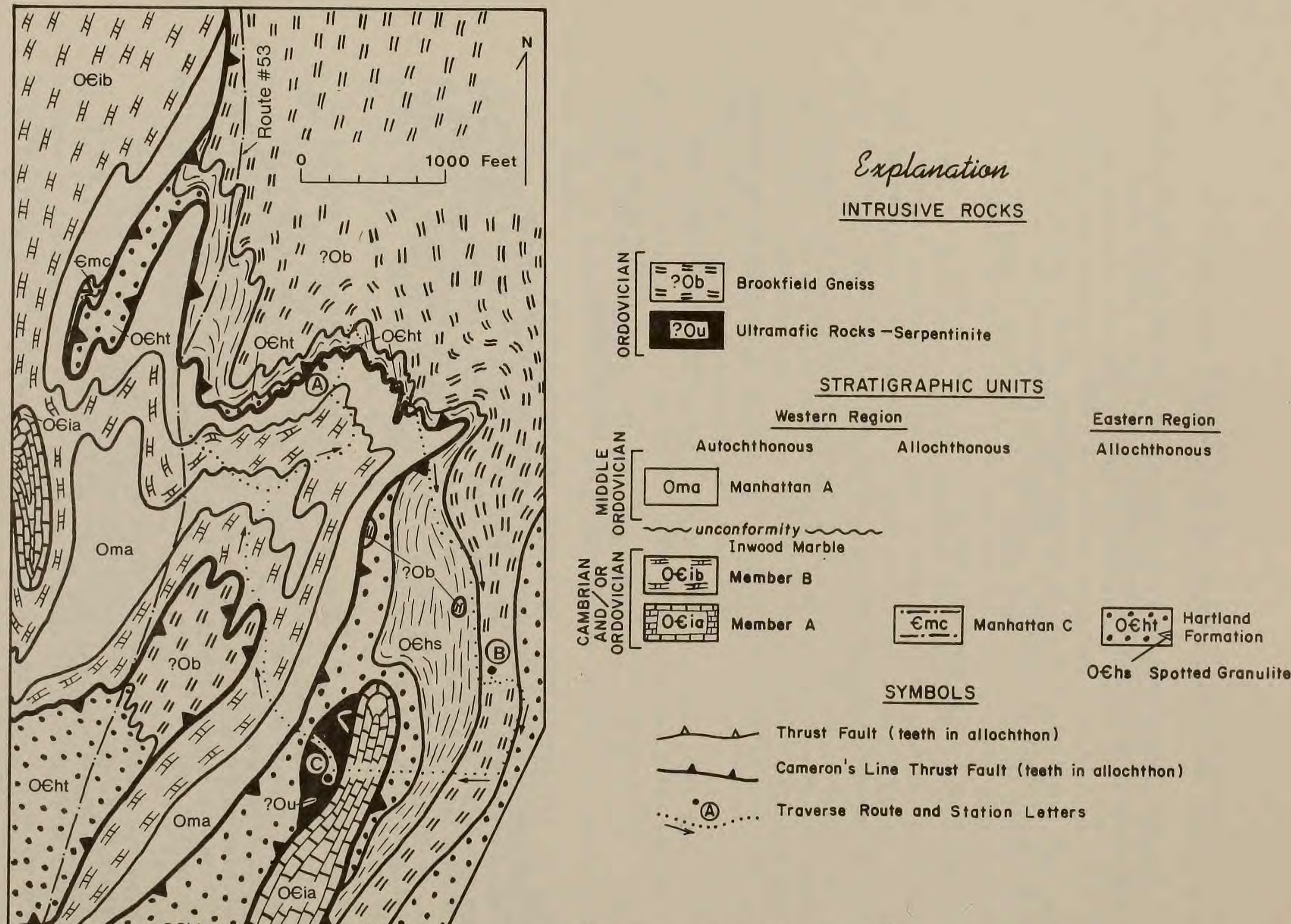

Figure 4. Geologic map showing traverse for Stop 3.

the top of the spur. A section of the Hartland Formation 40 feet thick is exposed here. The Cameron's Line Thrust Fault can be located to within 20 feet and is obscured by lack of outcrop. The Hartland Formation immediately above Cameron's Line consists of approximately 20 feet of thin bedded, light-gray biotite granulite, black amphibolite, and gray pinpoint-garnet-biotite granulite. A section of gray (sillimanite)-garnet-biotite spotted granulite with distinctive 1/8 inch crystals of white plagioclase is 20 feet thick and lies east of these various Hartland rocks which are overturned due to folding. This sub-unit is interpreted to be a sheared rock in the Hartland Formation, owing its texture to movement along the Cameron's Line Thrust Fault and/or tectonic movement of the overlying Brookfield Gneiss relative to the Hartland Formation.

Continue up the spur to the contact between the spotted granulite unit of the Hartland and the Brookfield Gneiss. Of particular interest here is that the degree of shearing within the Brookfield is greatest closer to Cameron's Line. This contact is interpreted to have been an original intrusive contact along which there has apparently been fault movement.

Compositional layering at the Brookfield-Hartland contact strikes N5°E and dips 57° west. Tight folds in the Hartland have an axial surface orientation that strikes N21°E and dips 55°NW and fold axes that plunge 42°, N72°W. These folds are interpreted to be third phase folds and to have developed during Acadian deformation.

The Brookfield Gneiss consists of gray (hornblende) -biotite-quartz-feldspar gneiss with distinctive megacrysts of K-feldspar and plagioclase that are up to 2 inches long. Compositional layering within the Brookfield strikes N31°E and dips 43°NW.

Proceed south to Bald Rock (Fig. 4, Station B). The Bald Rock outcrop consists of the Brookfield Gneiss with abundant feldspar megacrysts. Inclusions of biotite-hornblende gneiss up to 6 feet long and 4-5 inches wide are present within the Brookfield. Bald Rock affords a good view of the city of Danbury to the north.

Proceed south and then west, across an anticline in Cameron's Line to Station C at Serpentinite Hill (Fig. 4). The dull green, highly jointed rock exposed on this small hill is a very coarse grained serpentinite body that lies immediately above the Cameron's Line Thrust Fault. Compositional layering at the north end of the body strikes N10°E to N25°E and dips 73°W. Joints strike N40°W and dip 50° SW and are closely spaced.

Proceed northwest to the base of the hill, and then north. Note the isolated body of Brookfield Gneiss intrusive into the Hartland Formation along this final leg of the traverse. Return to the vehicles.

LUNCH

5.4	-	Proceed north along Route #53 to Reservoir St. in Bethel.
7.7	2.3	Turn left (west) onto Reservoir St.
8.0	0.3	Stop sign at intersection of Reservoir St. and Bethpage Drive. Outcrop of Manhattan A Marble Member on the right (north) side of the road.
8.2	0.2	View of Bogus Mountain (Precambrian Fordham Gneiss) to the left (south).
8.9	0.7	Turn right (east) into the Nature Center and follow the dirt road to the parking lot on the right.
9.1	0.2	Parking lot on right (south) side of Nature Center Road.

Stop 4. Nature Center Traverse. At this stop we will examine several rock types in Manhattan C exposed on a small hill south of the parking lot. Rock types in Manhattan C here include gray-weathering, sillimanite-garnet-biotite schistose gneiss, dark-gray to black, fissile sillimanite-garnet-biotite schist with sillimanite nodules and garnet-sillimanite-biotite schistose granulite.

Compositional layering in Manhattan C strikes N27°W to N30°W and dips 57° to 68° SW. Biotite and sillimanite lineations plunge 54°, N57°W at one location.

Contact relations with nearby Manhattan A are obscured by cover. The two hills to the west and south are underlain by calcite marble and rusty-weathering schist of Manhattan A.

These outcrops of Manhattan C are located in a doubly plunging first phase syncline that extends into the adjoining Danbury quadrangle to the north. The fold is interpreted to be downward closing and plunging northwest at both the south and north ends. The curvature of the fold hinge is extreme, with both north and south closures plunging moderately northwest. This curvature is interpreted to have occurred during the first phase of Paleozoic folding due to differential movement during the folding and not by a subsequent deformation, thus it is what is commonly referred to as a sheath fold.

9.1	-	Return to the vehicles and retrace route

		to the paved road (Mountainville Avenue).
9.3	0.2	Turn right (north) onto Mountainville Avenue.
9.5	0.2	View to west of Thomas Mountain which is underlain by the Biotite-Hornblende Gneiss Member of the Fordham Gneiss. The Lower Paleozoic unconformity is located at the east foot of Thomas Mountain.
10.2	0.7	Turn left onto Southern Boulevard.
10.4	0.2	Bear left onto Brushy Hill Road
11.6	1.2	Turn right onto Old Post Road.
11.8	0.2	Turn right onto Deal Drive and proceed up the hill. Outcrops of the Garnet-Biotite Gneiss and Amphibolite Member of the Fordham Gneiss on both sides of Deal Drive.
12.0	0.2	Proceed around the circle and retrace route back to Old Post Road
12.3	0.3	Park on the right (east) side of Old Post Road. The outcrops for Stop 5 are located on the east side of Brushy Hill Road, opposite from its intersection with Old Post Road.

Stop 5. Brushy Hill Road Pyroxenite, Danbury. At this stop we will examine a small body of biotite pyroxenite exposed near the base of the Hartland Formation, above the Cameron's Line Thrust Fault. The pyroxenite body is at least 50 feet long and is bordered on the east by schists of the Hartland Formation and a white granitic body. Petrographic study of the pyroxenite reveals that it is composed of augite, hornblende, biotite and minor plagioclase. This body is interpreted to have been intruded into the Hartland Formation prior to or during(?) the initial movement along Cameron's Line.

The rocks here are located on the west limb of a major second phase fold in Cameron's Line which refolds a major first phase syncline in Cameron's Line.

Nearby outcrops of the Hartland Formation consist of gray sillimanite-garnet-biotite gneiss. Compositional layering in this gneiss strikes N5°E and dips 68° west. It is uncertain whether the contact between the Hartland and the pyroxenite is entirely intrusive, tectonic, or in part both. Another ultramafic body, a hornblendite, is located approximately 1.5 miles south of here in a similar structural position.

12.3	-	Return to vehicles and proceed north to the intersection of Old Post Road and Brushy Hill Road.
12.4	0.1	Turn left (north) onto Brushy Hill Road and retrace route to Southern Boulevard.
13.7	1.3	Bear right onto Southern Boulevard and continue northeast to its intersection with Mountainville Avenue.
13.9	0.2	Turn right (south) onto Mountainville Avenue.
14.9	1.0	Bear left onto Reservoir Street.
15.4	0.5	Stop sign at Bethpage Drive. Proceed straight along Reservoir Street.
15.7	0.3	Stop sign at Grassy Plain Street (Route #53). Turn right (south) onto Grassy Plain Street.
16.0	0.3	Turn left onto South Street.
16.1	0.1	Stop sign at Blackman Street. Bear right along South Street.
16.3	0.2	Turn right onto Taylor Avenue. Cross railroad tracks.
16.5	0.2	Turn right into driveway for Vanderbilt Chemical Company.
16.5	-	Park in Vanderbilt Chemical Company parking lot.

<u>Stop 6. Brookfield Gneiss at the Vanderbilt Chemical Company, Bethel.</u> At this stop we will examine the Cameron's Line Thrust Fault at a point where the Brookfield Gneiss is in thrust contact with Inwood B of the autochthonous section. The Brookfield hill is the southern extension of the rocks at Shelter Rock in the Danbury Quadrangle (Clarke, 1958). Because of folding here, the Brookfield dips west beneath Inwood B. The Brookfield consists of gray biotite-hornblende gneiss with microcline megacrysts. Inclusions in the Brookfield are present near the west edge of the outcrop and consist of thin layers of garnet-biotite granulite and black amphibolite of the Hartland Formation. These layers of the Hartland Formation and the Brookfield Gneiss are folded though it is uncertain whether these folds occurred during one of the main phases of Paleozoic folding or whether the folds were produced in relation to thrust faulting during movement along the

Cameron's Line Thrust Fault. The Brookfield is extremely sheared here and the degree of shearing and production of mylonitic rocks appears to be a function of distance from Cameron's Line. The shearing within the Brookfield is interpreted to have been the result of thrusting against other competant rocks during transport into thrust contact with Inwood B. This mylonitic texture within the Brookfield is folded by folds that are generally interpreted to be third phase Paleozoic folds, however there are numerous candidates for earlier phase folds in the outcrop. Some of these folds may have developed as early as the thrusting along Cameron's Line. The general orientation of the axial surfaces of the folds is N30°E, 43°NW. The fold hinge lines and mineral lineations have a general plunge of 40°, N50°W. There are several gullies that are parallel to the strike of the Brookfield at this outcrop that may be the result of weathering of subsidiary shear zones within the Brookfield. The movement sense along the Cameron's Line Thrust Fault as deduced by assymetric feldspar megacrysts and the angular relationship between s- and c-surfaces indicates west-directed thrusting of the Brookfield.

16.5	-	Return to the vehicles. Turn left onto Taylor Avenue.
16.7	0.2	Turn right onto South Street. Cross railroad tracks.
16.8	0.1	Turn left onto Depot Place.
16.9	0.1	Jog left and right at the traffic light at the intersection of Depot Place and Greenwood Avenue.
17.0	0.1	Continue past Bethel Post Office on the left.
17.1	0.1	Turn left into the parking lot on the west side of the road opposite the Consolidated Controls Corporation plant on Wooster Street.

<u>Stop 7. Cameron's Line Thrust Fault at the Consolidated Controls Corporation, Bethel</u>. At this stop we will view the Cameron's Line Thrust Fault where the Hartland Formation lies in thrust fault contact with Inwood B of the autochthonous section. Apparently the Hartland Formation is truncated by Cameron's Line between this outcrop and the Brookfield at Stop 6, 0.75 miles to the south (Fig. 2).

The Hartland Formation exposed here consists of brown-weathering biotite-quartz-feldspar granulite that has a mylonitic texture along its contact with Inwood B. The production of this mylonitic texture is interpreted to be the result of thrusting of the Hartland against other competant rocks prior to their emplacement against Inwood B.

Inwood B consists of thin bedded, clean dolomite marble and silicate-mineral-rich dolomite marble with minor brown- and rusty-weathering quartzites. Accessory minerals in Inwood B marble include phlogopite, serpentine after forsterite, and some pyrite.

The outcrop dramatically shows at least three phases of folding involving the Cameron's Line Thrust Fault. Because of folding, Inwood B overlies the Hartland Formation in most of the outcrop, dipping moderately west.

Abundant minor folds, most of which are third phase folds, are present in this exposure. A poorly developed cleavage is parallel to the axial surface of the third phase folds and a pronounced mineral lineation is parallel to their hinge lines. Earlier isoclinal folds, inferred to be first phase folds, are refolded by third phase folds. Although these earlier folds may be second phase deformational features their axial planar foliation appears to be the first phase regional foliation. Therefore they are interpreted as first phase folds. The map scale fold is also inferred to be a first phase fold because of its relationship to these minor isoclinal folds.

There are later minor folds present that are open and have axial surface orientations that strike N62°W to N90°W and dip 55° to 65° NE to N. These open folds have a weakly developed axial surface foliation and are interpreted to be fourth phase folds. These folds may be associated with map scale folds that are reflected by broad changes in the regional map pattern of the rocks in southeastern New York and southwestern Connecticut.

17.1	-	To return to the Yale University Campus, exit from the parking lot and proceed to the traffic light at Greenwood Avenue.
17.3	0.2	Turn left onto Greenwood Avenue (Route #302).
17.6	0.3	Traffic light at intersection of Greenwood Avenue and Chestnut Street.
17.9	0.3	Bear left, staying on Greenwood Avenue (Route #302).
18.4	0.5	Traffic light at the intersection of Route #302 and Route #58 (Putnam Park Road). Turn right (south) onto Route #58. Follow Route #58 south through Redding, Aspetuck, and on to Fairfield.
		Intersection of Route #58 and the Merritt Parkway (Route #15). Proceed northeast along the Merritt to the exit for Route #34 east, which leads to New Haven.

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